SCIENCE DEMONSTRATIONS ON SKYLAB IN THE MATERIAL PROCESSING AREA

By

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SUMMARY

Twelve science demonstrations were accomplished on Skylab missions III and IV. These activities were defined in response to crew requests for time-gap fillers and were designed to be accomplished using onboard equipment. Nine of the demonstrations were in the area of materials science and space processing. They are described, and preliminary results are given. These nine science demonstrations are: Diffusion in Liquids, Ice Melting, Liquid Floating Zone, Immiscible Liquids, Liquid Films, Rochelle Salt Growth, Deposition of Silver Crystals, Fluid Mechanics Series, and Charged Particle Mobility.

INTRODUCTION

This paper discusses nine Marshall Space Flight Center (MSFC) science demonstrations in space processing (Table I) that were performed on Skylab missions III and IV. The objective of these demonstrations was to serve as time-gap fillers that would provide scientific data to be used for educational and scientific purposes. Each demonstration is briefly described, and a few results are discussed.

Most of the science demonstrations were performed on the last Skylab mission and used TV recording to obtain data. Therefore, the final reports from the investigators are not expected for a few months. For a written summary of the Skylab science demonstrations, see Skylab Science Demonstrations, a paper by Simon Ostrach which was presented at the March 1974 meeting of ESRO in Frascati, Italy [1], or NASA Technical Memorandum TM X-64835 entitled Skylab III and IV Science Demonstrations Preliminary Report [2].

TABLE I. SCIENCE DEMONSTRATIONS ON MATERIALS PROCESSING IN SPACE

Demonstration		SL-3	SL-4
(No number)	Diffusion in Liquids	X	
(No number)	Ice Melting	X	
TV101	Liquid Floating Zone		X
TV102	Immiscible Liquids		X
TV103	Liquid Films		X
TV105	Rochelle Salt Growth		X
TV106	Deposition of Silver Crystals		X
TV107	Fluid Mechanics		X
TV117	Charged Particle Mobility		X

SKYLAB III SCIENCE DEMONSTRATIONS

The first Skylab III demonstration was Diffusion in Liquids. Ms. Barbara Facemire of the Space Sciences Laboratory at MSFC was the investigator for this experiment. For Diffusion in Liquids, a 5-inch long by 0.75-inch diameter plastic forceps tube holder was used for the test tube. Pilot Jack Lousma injected the tube three-fourths full of water with a hypodermic syringe (Figure 1). A concentrated solution of instant tea (about 7 times normal drinking tea) was carefully placed on top of the water in the tube. The diffusion of the tea into the water was periodically photographed over a period of three days. The tea diffused a length of 0.75 inch in 45 hours. The final diffusion front was parabolically shaped, somewhat like a bullet, with very little diffusion occurring near the tube wall. This shape has so far been attributed to static charges on the forceps tube. This demonstration shows how slow pure diffusion processes without gravity-induced convection will be in space.

The second demonstration on Skylab III, Ice Melting, was performed also by Pilot Lousma. The investigators were Dr. Lewis Lacy of the Space Sciences Laboratory and Dr. Guenther Otto of the University of Alabama in Huntsville. In this demonstration a cylinder of ice was frozen on a cue tip in a pill dispenser bottle that was 2.5 inches long by 1 inch diameter. After remaining in the freezer for one day, the ice was removed from the pill bottle and mounted in front of the 35-mm camera. Periodic photographs of the ice melting were made. The rate of ice melting in zero gravity without buoyancy convection and the shape of the liquid on the unmelted ice portion were determined. The shape of the water went from cylindrical to ellipsoidal to circular in 4 hours (Figure 2). This demonstration illustrates how surface tension shapes liquid globules, altering the heat flow paths during melting.

Pilot Lousma had some free time after the ice melting demonstration was completed. It was decided to observe the effects of changing the surface tension of the globule with the addition of soap solution (Figure 3). Grape juice was added to the water globule for contrast. No distortion of the globule occurred when the soap was added. The soap diffused on the surface faster than inertial reaction because of surface tension gradients. Later, air was added to the interior of the globule. The cluster of air bubbles reached a critical size after which additional injections resulted in air bubbles popping out of the globule.

SKYLAB IV SCIENCE DEMONSTRATIONS

Because somewhat more time was available for planning the Skylab IV demonstrations, a science demonstration kit was flown to provide some critical hardware for use in these demonstrations. Even so, most of the hardware used was onboard hardware. The Skylab IV demonstrations were assigned numbers.

Demonstration TV101, Liquid Floating Zone, was proposed by Dr. John Carruthers of Bell Research Laboratories, Murray Hill, New Jersey. It was performed and recorded on TV video by Science Pilot Ed Gibson. This demonstration (Figure 4) simulates an important method of growing crystals and was done to define the stability of the liquid zone under a steady rotation rate of about 30 rpm as well as to obtain data on the instability modes and convection patterns. This information is important in the utilization of this technique for growing crystals both on the ground and in space in the planned Space Laboratory. Figure 4 is a schematic of the setup, while Figure 5 shows the setup in the Skylab mockup.

Demonstration TV102, Immiscible Liquids, was performed by Pilot William Pogue. The investigators were Dr. Lewis Lacy of the Space Sciences Laboratory and Dr. Guenther Otto of the University of Alabama in Huntsville. The objective of this demonstration was to photograph the coalescence of finely dispersed immiscible liquids. This demonstration visually defines some of the fluid dynamic aspects of the solidified immiscibles done on Skylab experiment M518. A metal clip containing three vials (2.5 by 0.5 inch) was flown in the science demonstration kit (Figure 6). Krytox and dyed water were used in the three vials containing 25, 50, and 75 percent water, respectively. The recoalescence of the fluids was rather fast (10 sec) on the ground (Figure 7). However, the emulsion appeared to remain stably mixed for up to 10 hours in space. This is shown on the film of the experiment.

Demonstration TV103, Liquid Films, utilized shaped strips of onboard safety wire (Figure 8) to create thin films of pure water and water containing a small amount of shower soap. The investigator for this demonstration was Wesley Darbro of the Space Sciences Laboratory. Commander Gerry Carr recorded this demonstration on TV video. He was able to obtain soap films that lasted longer than on the ground, but they did burst after 3 or 4 minutes. Commander Carr was able to obtain a sizeable pure water film during his practice runs (approximately 1 by 6 by 1/16 inch). The solidification of films from liquids which we are not able to accomplish on the ground appears feasible in space.

The next demonstration was TV105, Rochelle Salt Growth. The investigator was Dr. I. Miyagawa of the University of Alabama, Tuscaloosa. Pilot Pogue also performed this demonstration. A 4-inch food can was filled with saturated Rochelle salt solution, 8 gm of Rochelle salt powder, and a 22-gm Rochelle salt seed crystal. The can contained a see-through membrane under the pull-top lid. Pilot Pogue removed the pull-top lid in space, placed the can in the food heating tray (Figure 9), and then heated the solution until three-fourths of the seed crystal dissolved (at approximately 160° F). The can was removed, wrapped in several towels for insulation, and stowed. During storage in zero g, the seed crystal slowly regrew as the can cooled back down to cabin temperature over a period of two days, after which the towels were removed. Two weeks later, Pogue removed the seed crystal from the solution to observe the results in space. The solution contained many small Rochelle salt crystals that had nucleated from solution. Pogue described the solution as "slushy" and the nucleated crystals which he saw as being "mica-like." The seed crystal (Figure 10), which was returned to earth, had regrown in the form of a plate about 1.5 inches on each side and about 0.25 inch thick. The crystal was broken into three parts during handling in space. The seed crystal is polycrystalline, containing at least five crystals. A striking feature of this crystal is the existence of 0.1-mm diameter cavities, many of which are a centimeter in length. Cavities having a geometry such as that seen in the space-grown crystals have not been seen in crystals grown on earth. The five or more component crystals are oriented with the axes parallel. On earth the orientation of such crystals is usually random. A small part of the crystal is almost completely free of defects and appears extremely good optically. Measurements are being made at the University of Alabama, Tuscaloosa, on the ferroelectric hysteresis of selected parts of the crystal. It has been previously shown that the shape of the hysteresis curve yields the quality of Rochelle salt crystals (which are ferroelectric).

Demonstration TV106, Deposition of Silver Crystals, was also performed by Pilot Pogue. The investigator was Dr. P. Grodzka of Lockheed Missiles and Space Company, Huntsville. For this demonstration, a vial (2.5 by 0.5 inch) of dilute silver nitrate solution was flown in the science demonstration kit (Figure 11). In space, Pogue placed a scored copper wire in the vial. A slow chemical reaction between the copper and the solution produces silver crystals. On the ground these crystals are normally tree-shaped polycrystalline dendrites; in space long dendrites were formed which had small arms that could be described as "elongated" dendrite structures. As shown in the electron microscopic photograph (Figure 12), the earth-grown and space-grown silver crystals have a different microstructure (Figure 13). The microstructure of the space-grown material is composed of small crystallites that are more faceted and polygonal. (The space-grown material is also physically more powdery). Dr. Grodzka believes such new shapes may have application as new catalysts.

Demonstration TV107, Fluid Mechanics Series, consisted of several fluid demonstrations grouped under one heading. The investigators were Ms. Barbara Facemire and Mr. O. Vaughan of MSFC; Dr. S. Bourgeois of Lockheed Missiles and Space Company, Huntsville, Alabama; and Dr. T. Frost of the General Electric Company, Valley Forge, Pennsylvania. Both Science Pilot Ed Gibson and Pilot Pogue recorded this demonstration on TV video. It was essentially a series of tests (Figure 14) to obtain data on fluid oscillation times, dampening times, rotational instability, wetting characteristics, internal vortice, and fluid flow patterns. Over 2 hours of excellent data were obtained.

The last demonstration was TV117, Charged Particle Mobility. The primary investigator for this demonstration was Dr. Milan Bier of the Veterans Administration Hospital in Tucson, Arizona. Co-investigators were Dr. R. Snyder and Mr. S. Hall of Astronautics Laboratory at MSFC. Science Pilot Ed Gibson performed this demonstration. The objective was to study the movement of charged biological particles suspended in a solution in space. A pair of special test cells was fabricated at the

Veterans Hospital under the direction of Dr. Bier. These two cylindrical test cells had fluid cavities connected to each cell end. These components were mounted in a flight package at MSFC (Figure 15). An electrode was in each cavity, and a manually operated gate was installed at the cell entrance of the cavity containing the test specimen. The cavity of cell No. 1 contained human blood, while the cavity of cell No. 2 contained two proteins. Two buffer solutions were used in each cell to obtain a uniform diffusion front when the cell was operated. Twenty-eight volts were applied to the electrodes, and the gate was opened. The blood components moved down the cell under the influence of the electrical field (Figure 16). On the initial run in space, the front had a tendency to remain flat but was distorted by the presence of bubbles in the cell. Subsequently, Gibson reversed the potential, and the blood went back into the cavity. The crew was instructed real time to tap the unit in such a way that the bubbles moved to the opposite end. The experiment was then repeated (Figure 17). The blood migrated down the cell and showed a somewhat bullet-shaped front (the two buffer solutions on this run were now mixed). Unfortunately, the protein in cell No. 2 was exposed to ambient temperatures in the Command Module for approximately three weeks, which caused deterioration of the protein. No data were obtained from cell No. 2.

REFERENCES

1. Ostrach, Simon: Skylab Science Demonstrations. Presented at ESRO Space Processing Symposium, Frascati, Italy, March 25-27, 1974.

2. Bannister, Tommy C.: Skylab III and IV Science Demonstrations Preliminary Report. NASA Technical Memorandum TM X-68435, March 1974.

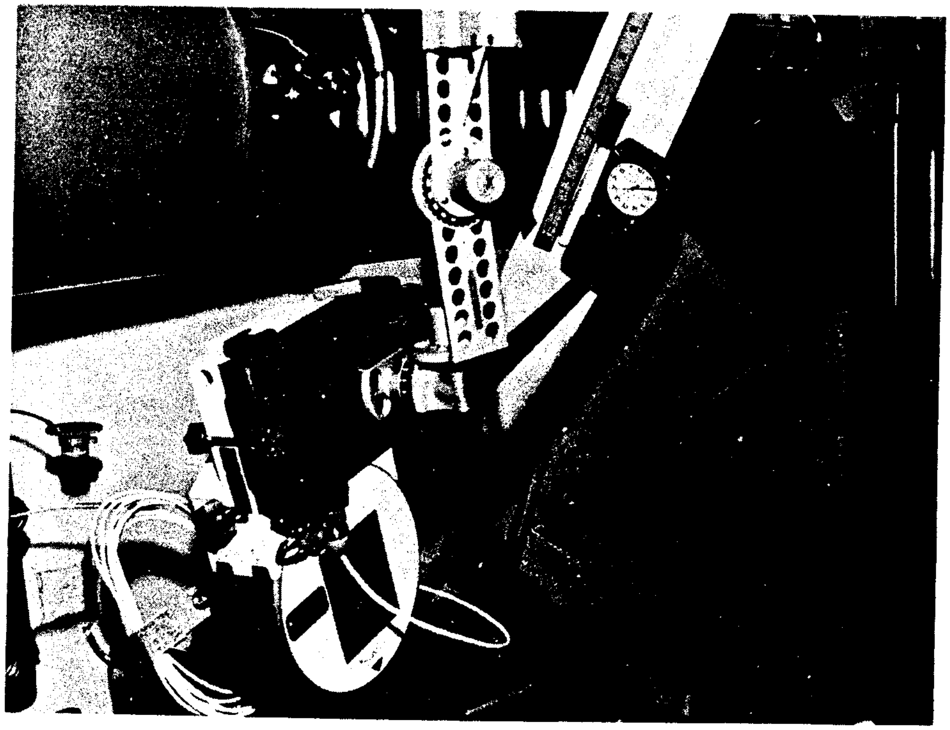


FIGURE 1. SKYLAB III SCIENCE DEMONSTRATION DIFFUSION IN LIQUIDS.

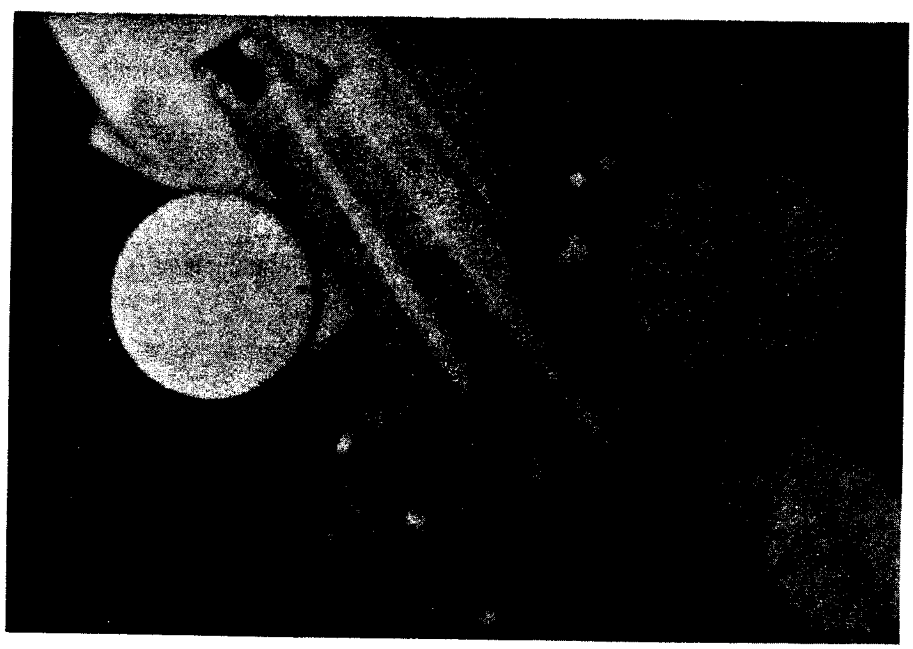


FIGURE 2. SKYLAB III SCIENCE DEMONSTRATIONS DIFFUSION IN LIQUIDS AND ICE MELTING.

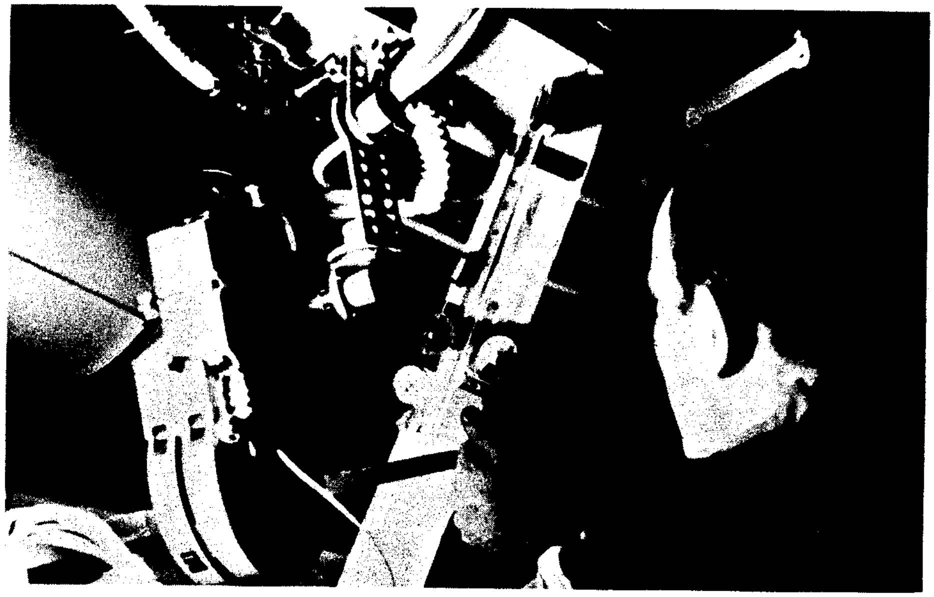


FIGURE 3. SKYLAB III SCIENCE DEMONSTRATION OF SURFACE TENSION EFFECTS.

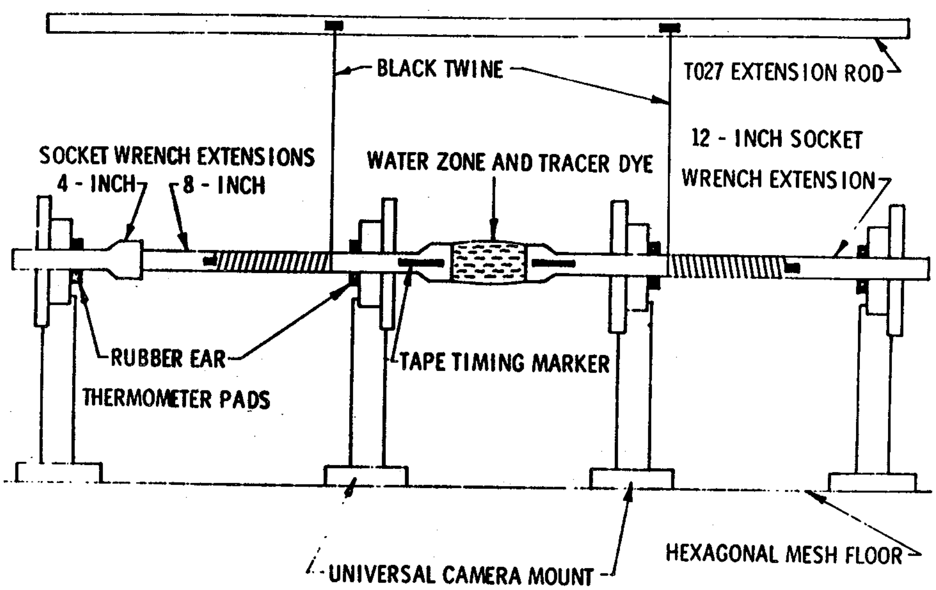


FIGURE 4. SCHEMATIC OF SKYLAB IV SCIENCE DEMONSTRATION TV101, LIQUID FLOATING ZONE.

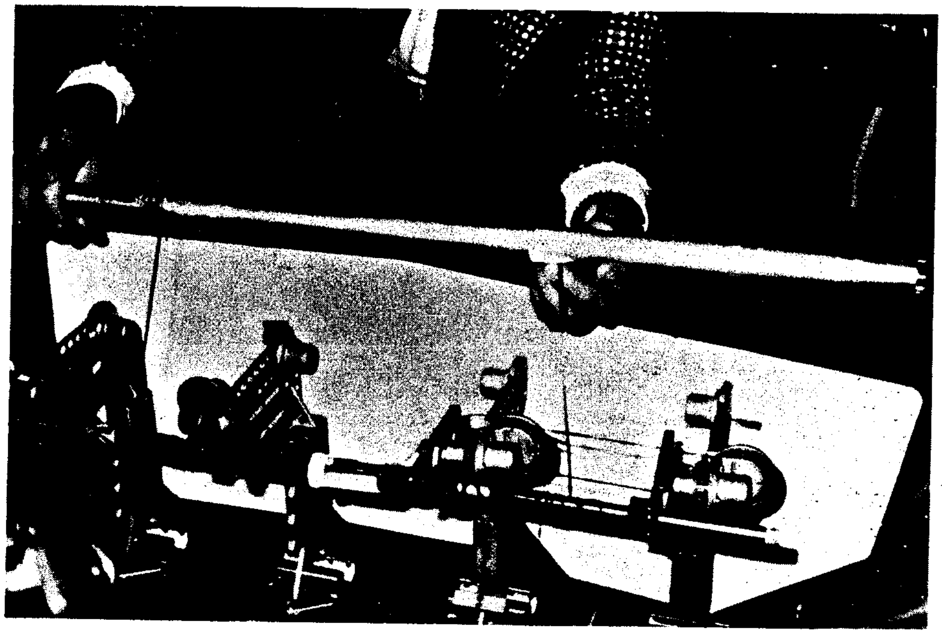


FIGURE 5. SKYLAB IV SCIENCE DEMONSTRATION TV101, LIQUID FLOATING ZONE.

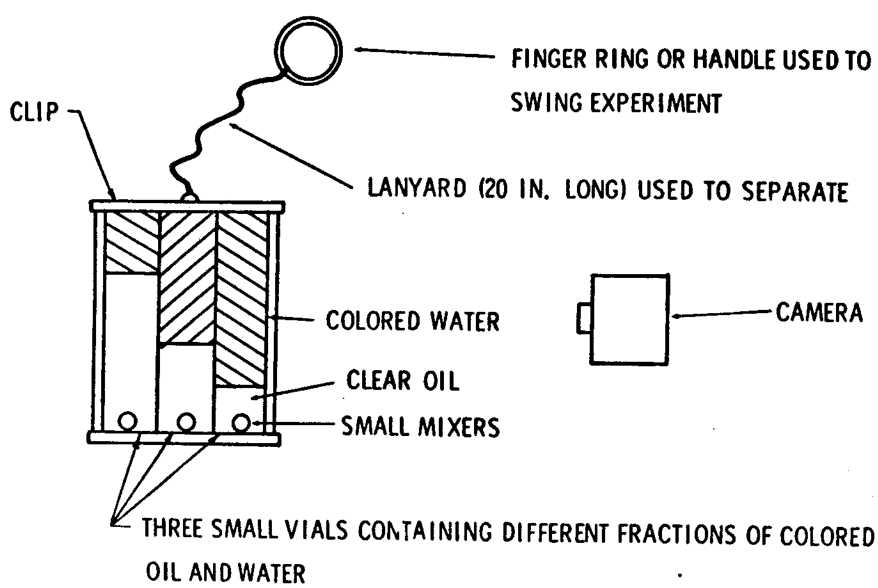


FIGURE 6. SKYLAB IV SCIENCE DEMONSTRATION TV102, IMMISCIBLE LIQUIDS.

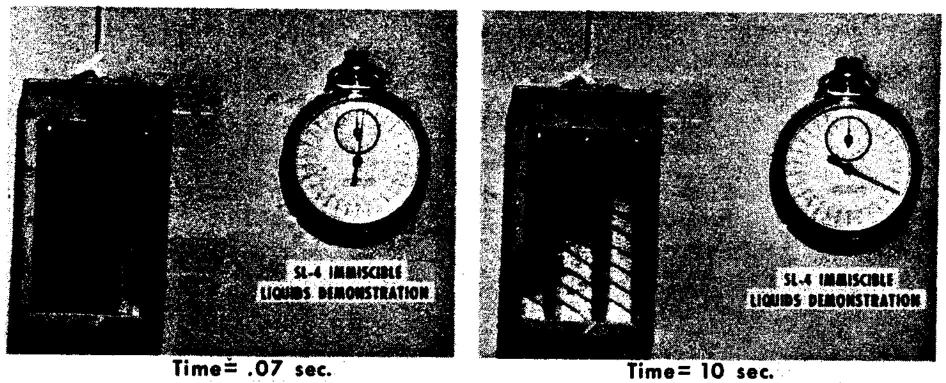


FIGURE 7. SKYLAB IV SCIENCE DEMONSTRATION TV102, IMMISCIBLE LIQUIDS, GROUND-BASED DATA.

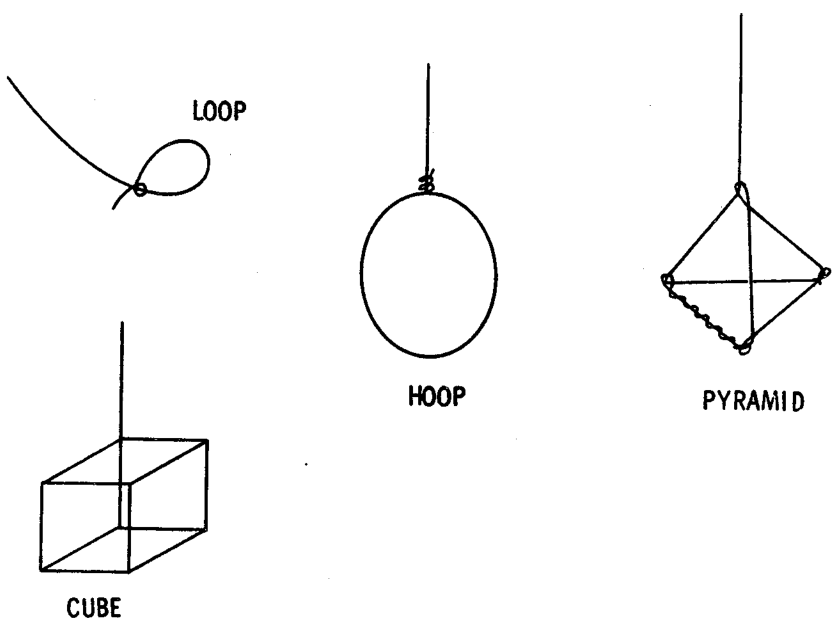
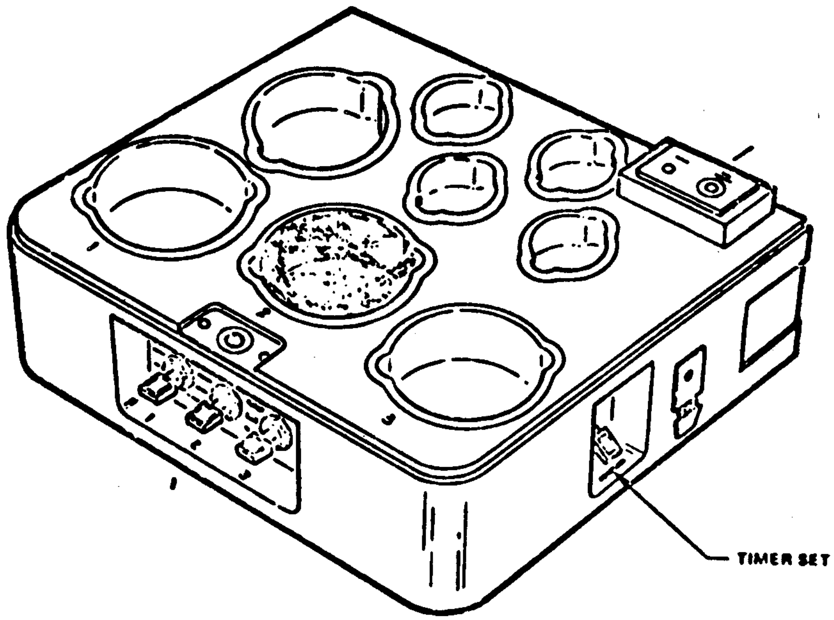


FIGURE 8. SKYLAB IV SCIENCE DEMONSTRATION TV103, LIQUID FILMS.



SPARE FOOD TRAY

- S/N 4909
- CAVITY 2 OPERATES AT 159° F

FIGURE 9. SKYLAB IV SCIENCE DEMONSTRATION TV105, ROCHELLE SALT GROWTH

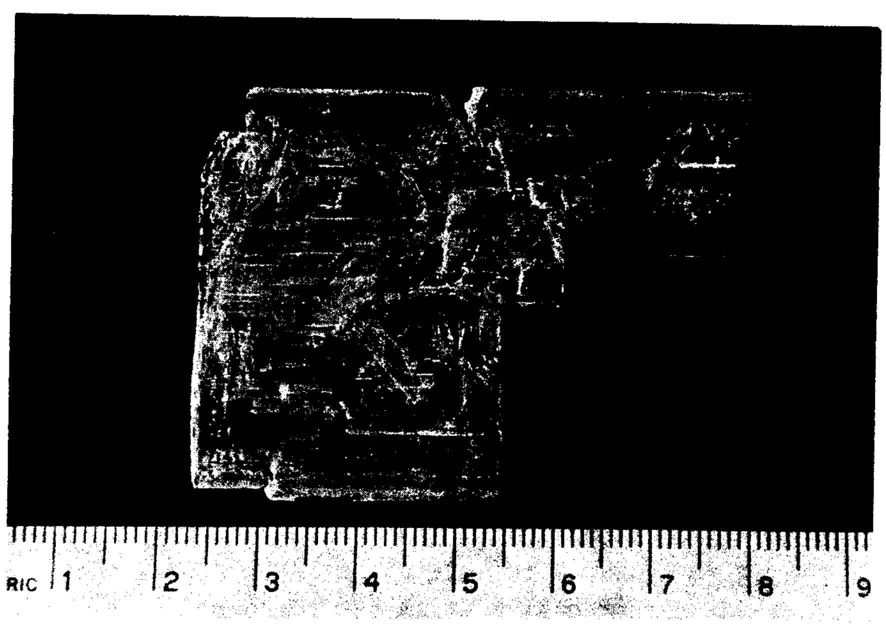


FIGURE 10. SKYLAB IV SCIENCE DEMONSTRATION TV105, ROCHELLE SALT GROWTH.

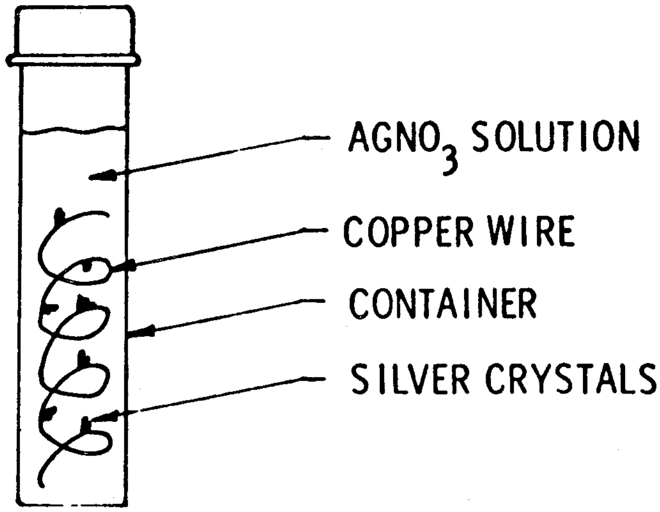


FIGURE 11. SKYLAB IV SCIENCE DEMONSTRATION TV106, DEPOSITION OF SILVER CRYSTALS.

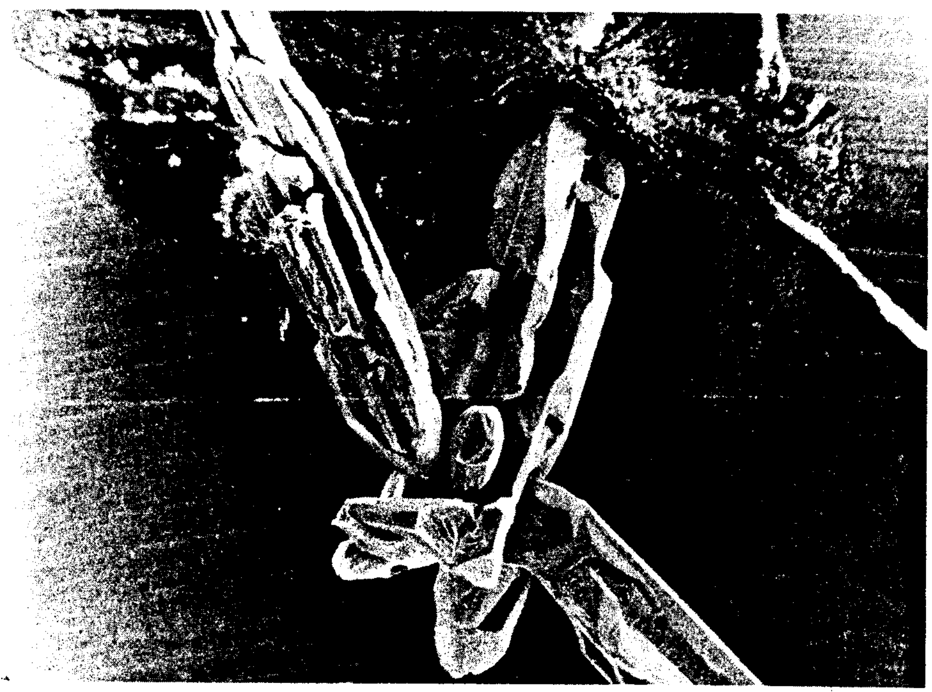


FIGURE 12. SKYLAB IV SCIENCE DEMONSTRATION TV106, DEPOSITION OF SILVER CRYSTALS, EARTH-GROWN (300X).

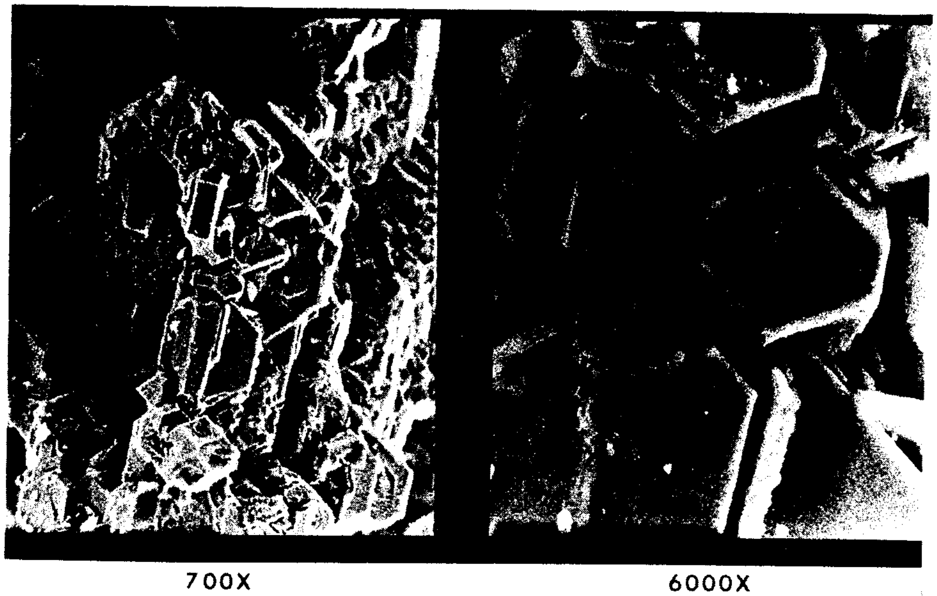


FIGURE 13. SKYLAB IV SCIENCE DEMONSTRATION TV106, DEPOSITION OF SILVER CRYSTALS, SPACE-GROWN.

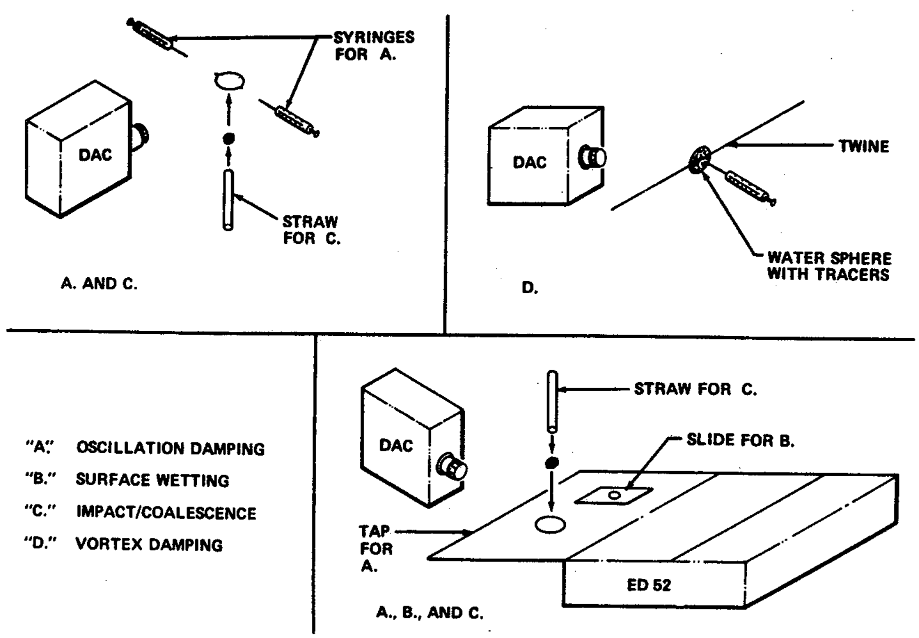


FIGURE 14. SKYLAB IV SCIENCE DEMONSTRATION TV107, FLUID MECHANICS SERIES.

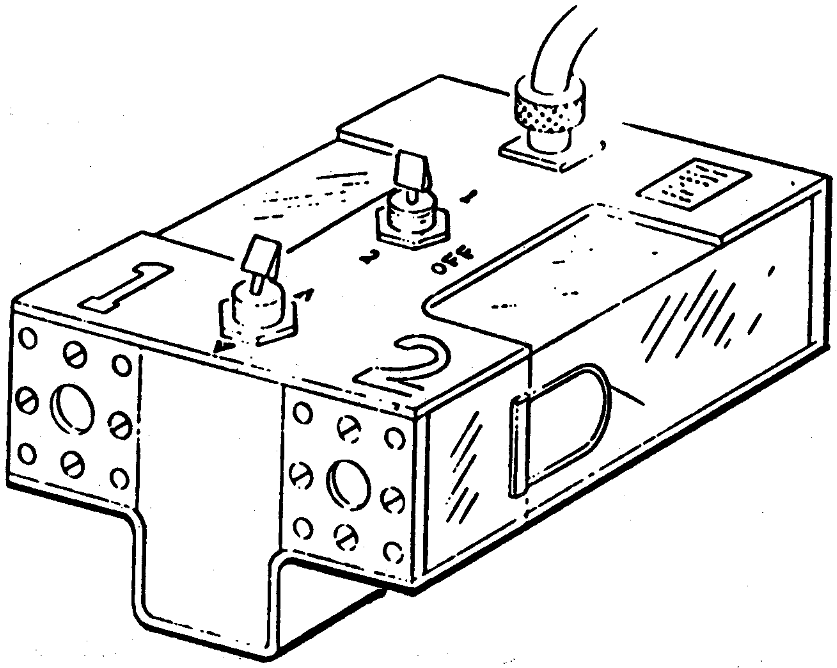


FIGURE 15. SKYLAB IV SCIENCE DEMONSTRATION TV117, CHARGED PARTICLE MOBILITY.

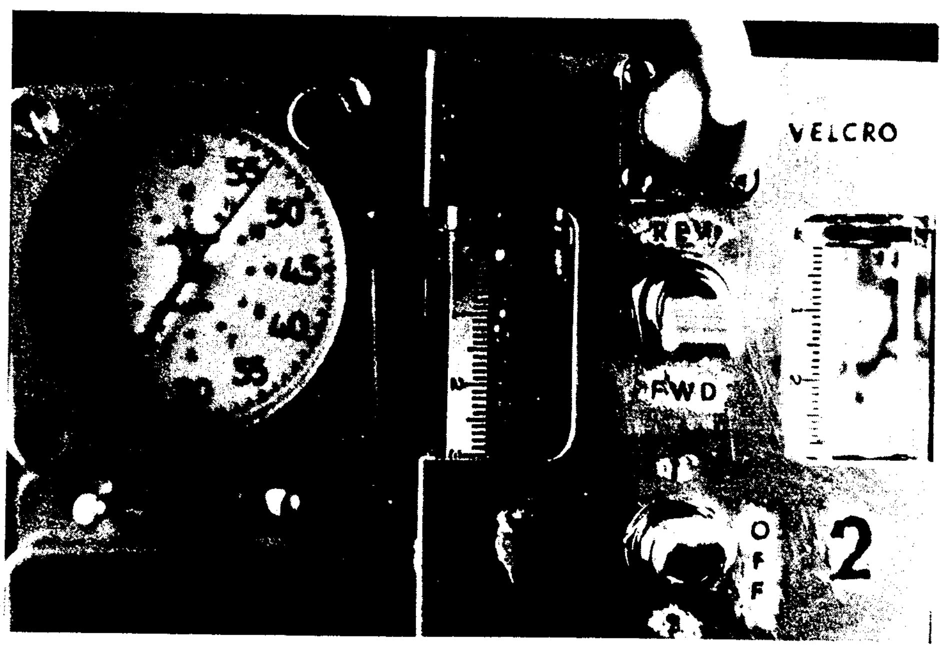


FIGURE 16. SKYLAB IV SCIENCE DEMONSTRATION TV117, CHARGED PARTICLE MOBILITY.

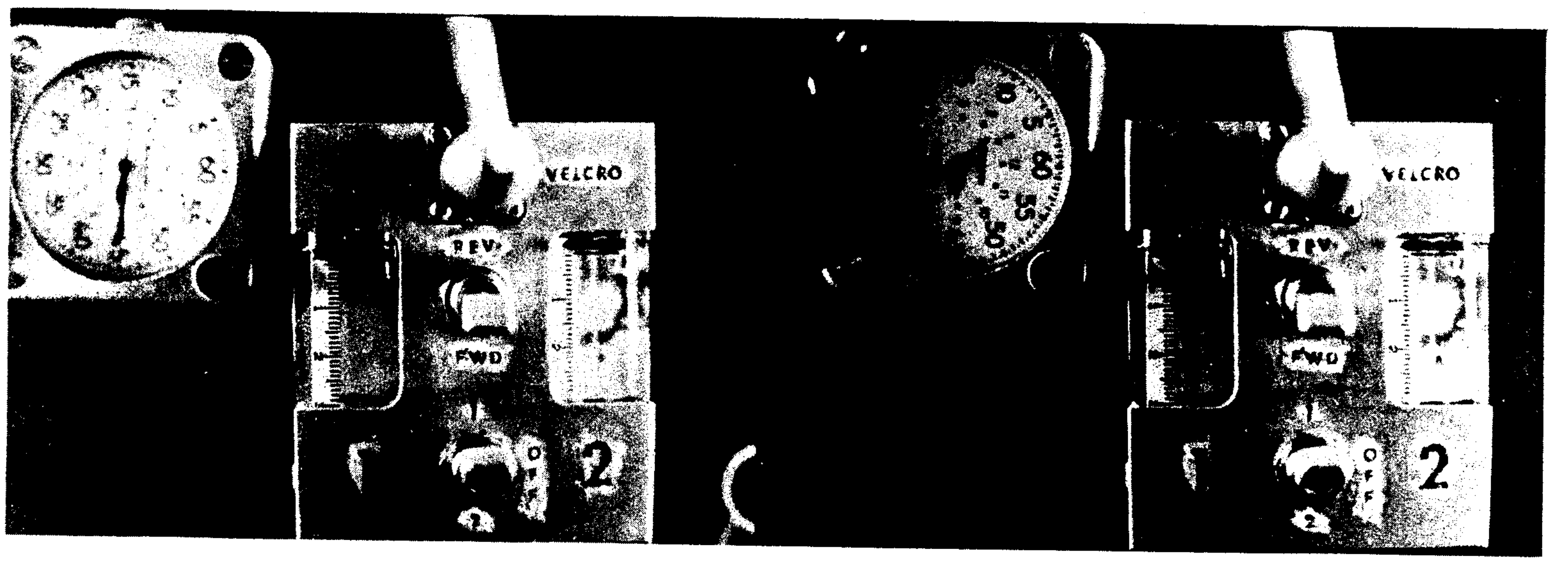


FIGURE 17. SKYLAB IV SCIENCE DEMONSTRATION TV117,
CHARGED PARTICLE MOBILITY.